The present invention relates to fluorinated carbon lubricating layers including dopants which provide thermal stability. The lubricating layers are extremely thin and are particularly useful for applications such as protective coatings for data recording media that are subjected to elevated temperatures during recording operations. Even though the lubricating layers are very thin, they have surprisingly been found to provide adequate wear resistance and corrosion protection for underlying recording media substrates while avoiding interference with data recording operations. The present invention represents a significant improvement over conventional lubricant coatings which must be substantially thicker in order to provide sufficient wear resistance and corrosion resistance.

By the present Amendment, Claim 1 has been amended to recite a recording medium comprising, in part, a lubricating layer having a thickness of less than 10 nm. Independent Claim 31 has been amended to recite a lubricated article comprising a substrate and a lubricant disposed on the substrate, wherein the lubricant comprises fluorinated carbon and a dopant comprising N and has a thickness of less than 10 nm. Independent Claim 34 has been amended to recite a method of magnetic recording comprising, in part, moving a magnetic recording medium in relation to a magnetic recording head, wherein the magnetic recording medium has a thickness of less than 10 nm. Basis for the language recited in amended Claims 1, 31 and 34 is provided in the specification, for example, at page 6, lines 14-16. No issue of new matter is presented.

Claim 35 has been amended to change the word "is" to "comprises", thereby clarifying that the dopant may include nitrogen as well as nitrogen-containing compounds. No issue of new matter is presented.

Newly added dependent Claims 39, 41 and 42 recite lubricating layer thickness of from 1 to 5 nm. Basis for the language recited in these claims is provided in the specification, for example, at page 6, lines 14-16. No issue of new matter is presented.

Newly added dependent Claim 40 recites that the dopant comprises N. Basis for the language of Claim 40 is provided in the specification, for example, at page 6, lines 1-3. No issue of new matter is presented.

Claims 31-33 stand rejected under 35 U.S.C. § 102(e) as allegedly being anticipated by Bray et al. '642. Bray et al. '642 discloses fluorine-doped diamond-like coatings containing carbon, silicon, oxygen, hydrogen and fluorine which may be deposited on various substrates. The thickness of the coating is from about 0.05 micron to about 10 microns (see column 3, lines 26-28). Thus, Bray et al. '642 teaches that a minimum thickness of 50 nm should be used. In contrast, amended independent Claim 31 recites that the lubricant has a thickness of less than 10 nm. One skilled in the art, reading the 0.05 to 10 micron thickness range of Bray et al. '642, would not be lead to make a coating having a thickness of less than 10 nm, which is 5 times less than the minimum thickness disclosed by the reference. Bray et al. '642 does not disclose that it would be possible to make a lubricating layer less than 10 nm thick, nor that such a thin layer would have adequate lubrication or protection properties. Since the presently claimed thickness is not taught or suggested by Bray et al. '642, it is submitted that Claim 31 is patentable thereover.

Claims 1, 2, 8-13, 15-16, 18-20, 31-34 and 36-38 stand rejected under 35 U.S.C. § 102(b) as allegedly being anticipated by Schmidt et al. '409. Claims 4 and 17 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Schmidt et al. '409. Claims 3-6 and 35 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Schmidt et al. '409 in view of Endo et al. Applied Physics Letters. Applicants respectfully traverse these rejections.

Schmidt et al. '409 discloses hydrogenated carbon compositions including optional elemental additions selected from fluorine, silicon, boron, oxygen, argon and helium (see column 1, lines 30-45). Schmidt et al. '409 teaches that the disclosed compositions may be employed as coatings for magnetic recording media. When the disclosed compositions are used as magnetic recording media coatings, Schmidt et al. '409 states that:

> The compositions of selected properties may be employed as the coatings for lubrication and corrosion protection, and work well when the slider makes contact with the disk. The surface coating must be a low friction, very thin, coating, preferably <u>500 Å thickness</u>. (emphasis added)

Thus, Schmidt et al. '409 discloses that a very thin lubricant coating for a magnetic recording disk would be 500 Å thick. The reference does not teach or suggest that it would be possible or desirable to produce a lubricating layer with a thickness of less than 10 nm, as presently claimed. One skilled in the art, reading the 500 Å thickness disclosed by Schmidt et al. '409, would not be lead to make a coating having a thickness of less than 10 nm as presently claimed. It is therefore submitted that independent Claims 1, 31 and 34 are patentable over Schmidt et al. '409.

The dependent claims recite additional features which further serve to distinguish over the prior art of record. For example, Claims 3-6, 35 and 40 recite that the dopant comprises nitrogen or a nitrogen-containing compound. The Office Action acknowledges that Schmidt et al. '409 does not disclose nitrogen-containing additions, and relies upon Endo et al. to supply this missing teaching. According to the Office Action:

> Schmidt does not teach the additional use of nitrogen or a nitrogen compound as a dopant in the layer. However Endo teach that Nitrogen enhances the thermal stability of a fluorinated carbon layer. Therefore it would have been obvious to one of ordinary skill in the art to add nitrogen in order to enhance thermal stability.

Applicants respectfully traverse this rejection. As disclosed at column 7, lines 3-11 of Schmidt et al. '409, the silicon, boron, fluorine and oxygen additions are introduced into the composition to provide desirable properties, while inert gas additives such as He or Ar are not believed to be incorporated into the formed composition. As acknowledged in the Office Action, Schmidt et al. '409 does not teach the addition of nitrogen or a nitrogen compound as a dopant.

Endo et al. discloses nitrogen-doped fluorinated carbon thin films for low dielectric constant interlayer dielectrics used in ultra-large-scale integration (ULSI) micro-electronic devices. Endo et al. does not teach or suggest any type of lubricating layer as presently claimed. It is submitted that one skilled in the art of lubricants would not look to dielectric materials for possible modifications of lubricant compositions. Accordingly, it is submitted that Schmidt et al. '409 and Endo et al. represent non-analogous art and cannot properly be combined.

Furthermore, although Endo et al. teaches that nitrogen may be added to a dielectric material in order to increase thermal stability, there is no teaching provided in either reference that nitrogen could be added to a lubricating layer as presently claimed. Absent such a teaching or suggestion, it is further submitted that the references cannot properly be combined. Therefore, dependent Claims 3-6, 35 and 40 further distinguish over the prior art of record.

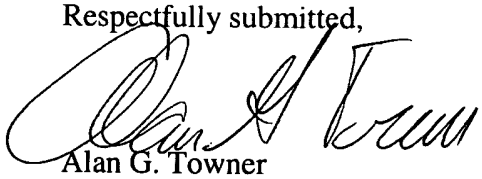
Dependent Claims 11 and 37 recite that the lubricating layer is thermally stable at a temperature above 250°C, while dependent Claims 12 and 38 recite that the lubricating layer is thermally stable at a temperature of 300°C. The prior art of record fails to teach or suggest lubricating layers having the thermal stabilities recited in these claims. Accordingly, Claims 11, 12, 37 and 38 further distinguish over the prior art of record.

Dependent Claim 13 recites that the recording medium comprises a buffer layer disposed between the recording layer and the lubricating layer, while dependent Claim 14 recites that the buffer layer comprises specific materials. Schmidt et al. '409 does not teach or suggest such buffer layers. Accordingly, these claims further distinguish over the prior art of record.

In view of the foregoing amendments and remarks, it is submitted that Claims 1-20 and 31-42 are patentable over the prior art of record. Accordingly, an early Notice of Allowance of this application is respectfully requested.

In the event that any outstanding matters remain in connection with this application, the Examiner is invited to telephone the undersigned at (412) 263-4340 to discuss such matters.

Respectfully submitted,



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Marked-up Version of Claims

1. (Amended) A recording medium comprising:

a substrate;

a recording layer disposed on the substrate; and

a lubricating layer disposed on the recording layer, wherein the lubricating layer comprises fluorinated carbon and a thermally stabilizing dopant, and has a thickness of less than 10 nm.

31. (Amended) A lubricated article comprising a substrate and a lubricant disposed on the substrate, wherein the lubricant comprises fluorinated carbon and a dopant [selected from the group consisting of compounds containing N and compounds containing SiO_2] comprising N and/or Si, and has a thickness of less than 10 nm.

34. (Amended) A method of magnetic recording comprising:

providing a magnetic recording head;

providing a magnetic recording medium; and

moving the magnetic recording medium in relation to the head to thereby record data, wherein the magnetic recording medium comprises a lubricating layer including fluorinated carbon and a thermally stabilizing dopant, and has a thickness of less than 10 nm.

35. (Amended) The method of magnetic recording of claim 34, wherein the thermally stabilizing dopant [is] comprises N.

New Claims 39-42

39. (New) The recording medium of claim 1, wherein the lubricating layer has a thickness of from 1 to 5 nm.

40. (New) The lubricated article of claim 31, wherein the dopant comprises N.

41. (New) The lubricated article of claim 31, wherein the lubricating layer has a thickness of from 1 to 5 nm.

42. (New) The method of the claim 34, wherein the lubricating layer has a thickness of from 1 to 5 nm.